REMARKS

Applicants are amending their claims in order to further clarify the definition of various aspects of the present invention, so as to facilitate proceedings in connection therewith. Specifically, Applicants have cancelled claim 1 and claims ultimately dependent thereon (claims 2, 7, 8 and 11-14), without prejudice or disclaimer. Moreover, Applicants have amended claim 3 to recite that the negative electrode contains amorphous carbon; and to delete recitation that AO comprises one or two or more of the oxyalkylene groups, and that p, q, r, α, β and γ each represent an average degree of polymerization of the oxyalkylene group. See, e.g., the last full paragraph on page 13, of Applicants' specification Applicants have amended claim 17 to recite AO, rather than A0.

Moreover, Applicants are adding new claims 22 and 23 to the application. Claims 22 and 23, each dependent on claim 3, respectively recites that the polymerizable composition consists essentially of, and consists of, the boron-containing compounds represented by the formula (2) and by the formula (3). Note, for example, Examples 10-30, and note in connection therewith Table 1 on page 16 of Applicants' specification.

The rejection of claims 1-21 under the second paragraph of 35 USC 112, as being indefinite, set forth in Item 2 on pages 2 and 3 of the Office Action mailed February 14, 2008, is noted. Insofar as this rejection is applicable to claim 1 and claims dependent thereon, such rejection is moot in view of cancelling of claim 1 and claims dependent thereon without prejudice or disclaimer.

Insofar as this rejection under the second paragraph of 35 USC 112 is applicable to claim 3 and claims dependent thereon, note that claim 3 has been amended to delete recitation that AO "comprises one or two or more of the oxyalkylene group", and has also been amended to delete recitation that "p, q, r, α, β

and γ each represent an average degree of polymerization of the oxyalkylene group. In view of the deletion of recitations in claim 3, it is respectfully submitted that bases for rejection of claim 3 under the second paragraph of 35 USC 112, as set forth in the paragraph bridging pages 2 and 3 of the Office Action mailed February 14, 2008, are moot.

The rejection of claim 17 "because A0 should be AO" is moot, in light of amendment of claim 17 to recite "AO".

Applicants respectfully traverse the rejection of claim 19 "because it is unclear how this further limits [claim 3]". Thus, note that claim 3 recites that each of the sum p+q+r and the sum α+β+γ is one or more, while claim 19 recites that p, q, r, α, β, and γ are 1-3, with the sums of p+q+r and α+β+γ being 3-9. It is respectfully submitted that claim 19 further defines the above-referenced subscripts, and is not indefinite.

Applicants respectfully submit that all of the claims now presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action mailed February 14, 2008, that is, the teachings of U.S. Patent No. 6,833,220, International (PCT) Published Application No. WO 01/18094/U.S. Patent No. 7,045,242, European Patent Application No. 1,160,268, Japanese Patent Document No. 2002-348323 to Yokoyama, et al., and International (PCT) Publication No. WO 03/031453/U.S. Patent No. 6,998,465, under the provisions of 35 USC 102 and 35 USC 103.

Initially, note that Applicants have cancelled claim 1 and claims dependent thereon. Accordingly, insofar as the rejection set forth in Item 5 on page 5 of the Office Action mailed February 14, 2008, is directed to claim 1 and claims dependent thereon, such rejection is moot.

Insofar as the rejection as set forth in Item 5 on page 5 of the Office Action mailed February 14, 2008, is directed to claims ultimately dependent on claim 3 (that is, claims 15-21), it is respectfully submitted that Japanese Patent Document No. 2002-348323, and International (PCT) Application No. WO 03/031453 would have neither disclosed nor would have suggested such lithium secondary battery as in the present claims, including, inter alia, wherein the ion conductive material comprises a polymerizable composition which contains a boron-containing compound represented by the formula (2) and a boron-containing compound represented by the formula (3). In this regard, it is emphasized that in discussing No. 2002-348323 and No. WO 03/031453, the Examiner has not rejected parent claim 3, and has not even referenced formula (3). Clearly, the Examiner has not established that either of No. 2002-348323 or No. WO 03/031453 would have been anticipatory of the subject matter claimed in claim 3 and claims dependent thereon.

Applicants respectfully submit that all of the claims remaining in the above-identified application patentably distinguish over the teachings of prior art applied by the Examiner in rejecting, inter alia, claim 3 and claims dependent thereon in the Office Action mailed February 14, 2008, that is, the teachings of European Patent Application No. 1,160,268, International (PCT) Application No. WO 01/18094/US Patent No. 7,045,242, and U.S. Patent No. 6,833,220, under the provisions of 35 USC 102 and 35 USC 103.

It is respectfully submitted that these references as applied by the Examiner would have neither taught nor would have suggested such a lithium secondary battery as in the present claims, having, inter alia, the electrolyte containing an ion conductive material and an electrolytic salt, and wherein the ion conductive material comprises a polymerizable composition which contains boron-containing compounds respectively represented by the formula (2) and the formula (3), each being boron-

containing compounds, and with each of Z_4, Z_5 and Z_6 representing an organic group having an acryloyl group or a methacryloyl group or a hydrocarbon group of 1-10 carbon atoms, with the proviso that at least one of Z_4, Z_5 and Z_6 is an organic group having an acryloyl group or a methacryloyl group, and with R_1, R_2 and R_3 each representing a hydrocarbon group of 1-10 carbon atoms, AO representing an oxyalkylene group of 1-6 carbon atoms, and each of the sum of p+q+r and the sum of α+β+γ being one or more. See claim 3.

Note that each of the compounds of formulas (2) and (3) is a boron-containing compound; and note that one of these compounds, containing R_1-R_3 as recited in the present claims, has no functional groups at terminal locations, providing advantages as discussed infra.

More specifically, it is respectfully submitted that these references as applied by the Examiner would have neither disclosed nor would have suggested such a lithium secondary battery as in the present claims, having features as discussed previously in connection with claim 3, and wherein the polymerizable composition consists essentially of the boron-containing compounds of the formulas (2) and (3), as in claim 22, or wherein such polymerizable composition consists of the boron-containing compounds represented by the formulas (2) and (3), as in claim 23.

In addition, it is respectfully submitted that these applied references would have neither taught nor would have suggested such lithium secondary battery as in the present claims, including the compounds of the formula (2) and of the formula (3) as in claim 3, and wherein these compounds are included in a molar ratio of the compound of formula (2) to the compound of the formula (3) of 0.1-9 (see claim 4); more specifically, 0.5-4 (see claim 20), even more specifically, 1-2.5 (see claim 21).

Furthermore, it is respectfully submitted that these applied references would have neither taught nor would have suggested such a lithium secondary battery as in

the present claims, having features as discussed previously in connection with claim 3, and, moreover, wherein the electrolyte contains a polymer obtained by polymerizing the polymerizable composition recited in claim 3 (note claims 5 and 6); and/or the further definition of p, q, r, α, β and γ, as in claim 19; and/or molecular weights of the compounds of the formulas (2) and (3), as in claims 15 and 16; and/or number of carbon atoms in AO, as in claim 17; and/or wherein all of Z_4, Z_5, and Z_6 are organic groups having an acryloyl group or a methacryloyl group (see claim 18); and/or the electrolytic salt included with the ion conductive material discussed previously, as in claims 9-10.

The present invention is directed to a lithium secondary battery. Recently, there have been proposed secondary batteries utilizing solid electrolytes, including organic polymers. Organic polymers are generally superior in processability and moldability as compared to other solid electrolytes, e.g., inorganic materials, and, as a result, it is expected that organic polymers will be further useful in lithium secondary batteries in the future.

However, a defect in previously proposed organic polymer electrolytes in such secondary batteries is an inferior ionic conductivity. The previously proposed polymer electrolytes have such poor ion conductivity that sufficient current density at the time of charging and discharging of batteries cannot be obtained, and such polymer electrolytes are not applicable for heavy current use. That is, previously proposed polymer electrolytes do not have a value of ionic conductivity (1mS/cm or higher at room temperature) which is required in practice for electrolytes of lithium secondary batteries. See the last full paragraph on page 2 of Applicants' specification. And previously proposed polymer electrolytes have inferior high rate discharge characteristics.

Against this background, Applicants provide an ion conductive material having satisfactory ionic conductivity and good high rate discharge characteristics, yet which can easily be made and has other effective properties for an ion conductive material of a lithium secondary battery. Specifically, Applicants have found that by utilizing boron-containing compounds as in the present claims, having a relatively small number of oxyalkylene groups (that is, where p, q, r, α, β and γ are each more than 0 and less than 4, the sum of p, q and r, and of α, β and γ, each being 1 or more, objectives of the present invention are achieved, and, in particular, an electrolyte is provided having sufficient ionic conductivity, and good high rate discharge characteristics.

That is, the compounds of the present invention, utilized as the ionic conductive material, contains boric acid ester and have a specific number (limited) of polyoxyalkylene groups. Such specific molecular structure of the present invention achieves good mobility of the molecule chain and high boron concentration at the same time, so that there are simultaneously achieved high ion conductivity, good initial charging capacity, long cycle performance and high rate discharging characteristics.

It is emphasized that according to the present invention, the compounds of both formulas (2) and of formula (3) contain boron. Accordingly, sufficient ion conductivity is obtained.

In addition, the compound of formula (3) does not include a polymerizable functional group, so that an increase of the modulus of elasticity of the polymerized compound, resulting in a polymeric compound of high hardness, can be avoided.

In addition, the polymer electrolyte of the present invention can obtain high ion conductivity without the need of a non-aqueous solvent such as a carbonate, and hence is also relatively safe.

Attention is respectfully directed to Examples 1-30 in Table 2, on page 52 of Applicants' specification. From this Table, it can be seen that it is important for the number of oxyalkylene groups (that is, p, q, r, α, β and γ) are more than 0 and less than 4, with sums as in claim 3. With the number of "AO" groups as in the present claims, whereby the compounds are relatively small, a reduction in mobility of the polymer chain can be avoided; and, as a result, ion conductivity of the ion conductive material is high. From this Table, it can also be seen that it is important that the terminal groups (Z_1, Z_2 or Z_3) other than the acryloyl or methacryloyl groups be a hydrocarbon group of 1 to 10 carbon atoms.

Moreover, if the number of "AO" groups is relatively large, e.g., up to 600 as in claims of U.S. Patent No. 6,998,465, discussed infra, it is impossible to attain sufficient ion conductivity as well as initial discharge capacity, cycle performance and high rate discharge characteristics, as seen from Comparative Examples 1 and 2 in Table 2 on page 52 of the above-identified application.

That is, Comparative Example 2 uses a polymer electrolyte containing (1) a polymerizable boron-containing compound having an average number of oxyalkylene groups of 12, and (2) a boron-containing compound having an average number of oxyalkylene groups of 8. The boron-containing compounds in this Comparative Example is poor in ion conductivity, initial discharge capacity, cycle performance and high rate discharge characteristics.

It is respectfully submitted that this evidence of record, which must be considered in determining patentability of the presently claimed subject matter, establishes unexpectedly better results achieved by the present invention, as compared to the closest prior art.

While Applicants relied on the evidence in their specification, in previous Amendments, e.g., on pages 10-12 of the Amendment submitted March 5, 2007, and

on pages 11 and 12 of the Amendment filed October 1, 2007, the Examiner did not address this evidence. Such failure to address evidence of record is clearly improper. See Manual of Patent Examining Procedure 716.01. It is respectfully submitted that upon review of the evidence of record, such evidence shows unexpectedly better results achieved by the present invention, and, correspondingly, supports patentability thereof.

U.S. Patent No. 6,833,220 discloses an electrolyte, for secondary batteries, which is a polymer electrolyte, the electrolyte including an ionic compound and an organic polymer compound, the organic polymer compound comprising a compound represented by the general formula (1) or (2) (see column 2 of the patent) or a polymerization product of a boric acid ester compound obtained by the esterification of the compound represented by the general formula (1) or (2) with boric acid or boric anhydride. Note, in particular, column 2, lines 21-38; and column 2, line 50, through column 3, line 8. See also the paragraph bridging columns 6 and 7 of this patent. The Examiner has also referred to column 34 of this patent, column 34 setting forth fully therein claims 2-7 and the first two lines of claim 8, the Examiner referring to a specific formula set forth in claim 4 thereof.

It is respectfully submitted that in No. 6,833,220, all of the boron compound molecules have polymerizable functional groups, so that crosslinking density of the resulting polymer compound becomes high and its elastic modulus is high. In contrast, note that R_1, R_2 and R_3 in claim 3 each represent a hydrocarbon group of 1-10 carbon atoms. That is, R_1, R_2 and R_3 are not polymerizable functional groups. It is respectfully submitted that No. 6,833,220 would have neither disclosed nor would have suggested the presently claimed invention, including, inter alia, the compound of the formula (3), and advantages thereof.

Furthermore, note that No. 6,833,220 discloses that the compound can have as many as 600 oxyalkylene groups. It is respectfully submitted that the resulting polymer compound would have poor mobility, and, consequently, ionic conductivity of the polymer compound would be low. It is respectfully submitted that No. 6,833,220 would have neither taught nor would have suggested the number of "AO" groups as in the present claims, and advantages thereof.

In summary, it is respectfully submitted that No. 6,833,220 does not disclose, nor would have suggested, the battery as in the present claims, including the ion conductive material having the number of oxyalkylene groups as in the claims; or having, the additional compound containing boron atom and without polymerizable functional groups as in the compound of formula (3) in the present claims, and advantages thereof.

The contention by the Examiner that No. 6,833,220 teaches the presently claimed subject matter "when l = 1-4" is respectfully traversed. Again, it is respectfully submitted that No. 6,833,220 has all terminals of the starting compounds with polymerizable functional groups, so that crosslinking density of the resulting polymer becomes high and elastic modulus is high; and, consequently, ion conductivity of the polymeric compound is low, whereby No. 6,833,220 does not achieve advantages of the present invention.

European Patent Application No. 1,160,268 discloses ion-conductive polymeric compounds, a polymeric electrolyte and an electric device using the same, the ion-conductive polymeric compounds having one or more trivalent boron atoms in the polymeric structure. Note particularly the third ion-conductive polymeric compound disclosed in No. 1,160,268, described in paragraphs [0035]-[0039] on pages 6 and 7 of this patent document, obtained by polymerizing a mixture of compounds represented by the general formulas (9) and (10), the compound

represented by formula (10) not containing boron, with Y in formulas (9) and (10) representing a polymerizable functional group. Note also paragraph [0040] on page 7 of this patent document, describing R^{11} and R^{12} in formula (9).

International (PCT) Publication No. WO 01/18094 as seen in U.S. Patent No. 7,054,242, discloses an ion-conductive polymeric compound, a polymeric electrolyte and an electric device using the same, with an ion-conductive polymeric compound having one or more trivalent boron atoms present in the polymeric structure. Note column 1, line 48, through column 2, line 4. Note especially the third ion-conductive polymeric compound in column 4, line 25, through column 5, line 36. Note that European Patent Application No. 1,160,268 corresponds to No. WO 01/18094.

In the following, the teachings of No. 1,160,268, No. WO 01/18094 and U.S. Patent No. 7,045,242 will collectively be referred to as Nishiura, et al.

Note that while the compound of the formula (9) in Nishiura, et al. contains a boron atom and a polymerizable functional group, the compound of formula (10) of Nishiura, et al. contains no boron atom, but contains a polymerizable functional group. It is respectfully submitted that the compound of formula (10) of Nishiura, et al. is different from the compound of formula (3) according to the present invention, which contains a boron atom but no polymerizable functional group.

It is respectfully submitted that the resulting ion-conductive polymeric material in Nishiura, et al., is low in boron content because of the absence of the boron atom in the compound (10), so that sufficient ion conductivity cannot be obtained; and, moreover, since in Nishiura, et al. both of the compounds (9) and (10) have polymerizable functional groups, the modulus of elasticity becomes high with increase of crosslinking density, resulting in a high hardness of the polymeric compound. Moreover, the number of oxyalkylene groups in Nishiura, et al. is high,

i.e., at least 4.8, so that mobility of the polymer chain is poor. As a result, ion conductivity of the ion conductive material in Nishiura, et al. is low.

It is respectfully submitted that Nishiura, et al. would have neither taught nor would have suggested the present invention, including wherein both compounds forming the ion conductive material are boron-containing compounds, and also wherein one of the compounds contains no polymerizable functional groups, and also wherein the number of oxyalkylene groups is relatively low, and advantages thereof.

The rejection of claims 1 and 2 on the ground of nonstatutory obviousness-type double patenting, over claims 6, 9, 11 and 13 of U.S. Patent No. 6,998,465, set forth in Item 7 on page 6 of the Office Action mailed February 14, 2008, is moot, in light of cancelling of claim 1 and claims dependent thereon.

Applicants respectfully traverse the nonstatutory obviousness-type double patenting rejection over claims 1-9 of U.S. Patent No. 7,230,057, particularly insofar as this rejection is applicable to the claims as presently amended. Thus, note that the present claims recite a lithium secondary battery, and recite that the negative electrode of this battery contains amorphous carbon.

No. 7,230,057 claims a polymerizable composition and an ion-conductive polyelectrolyte (the polyelectrolyte being claimed in claims 3-7). It is respectfully submitted that the claims of No. 7,230,057 do not disclose, nor would have suggested, a lithium secondary battery as in the present claims, including, inter alia, the positive and negative electrodes including in particular wherein the negative electrode contains amorphous carbon, as in all of the present claims.

Note that on page 13 of Applicants' specification, it is described that various materials can be used for the negative electrode. Especially in view thereof, it is respectfully submitted that the Examiner has not established propriety of the

obviousness-type double patenting rejection in view of the polyelectrolyte claimed in No. 7,230,057, it being emphasized that No. 7,230,057 does not claim a lithium secondary battery or a negative electrode, much less that the negative electrode contains amorphous carbon.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims remaining in the above-identified application, are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 500.42907PX1), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

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